08-10-00

UTILITY PATENT APPLICATION TRANSMITTAL UNDER 37 CFR 1.53(b)

ATTORNEY DOCKET 81225THC
Customer No. 01333

To: Commissioner for Patents
Box Patent Application
Washington, D.C. 20231

Express Mail Label No.

EL485199237US

Date: August 9, 2000

LOCATION OF EXTENDED LINEAR DEFECTS

First Named Inventor (or Application Identifier):
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Enclosed are:

1. [X] Specification
2. [2] Sheet(s) of drawing(s)
3. [X] Information Disclosure Statement Under 37 CFR 1.97.
4. Combined Declaration for Patent Application and Power of Attorney:
   4a. [X] New
   4b. [ ] Copy from a prior application (37 CFR 1.63(d)) (for continuation/divisional with Box 11 completed)
5. [ ] Incorporation by Reference (useable if Box 4b is checked) The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. [X] Assignment of the invention to **Eastman Kodak Company**
7. [ ] Certified copy of a priority document
8. [ ] Associate Power of Attorney
9. [ ] Deletion of Inventor(s). Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
10. [ ] If a 111A application prior to examination of the above-identified application, amend the specification at Page 1, after the title, by inserting the following:
    --CROSS REFERENCE TO RELATED APPLICATION
    Reference is made to and priority claimed from U.S. Provisional Application Serial No. , filed , entitled .

If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

11. [ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: ,
12. [X] Please address all written communications to Thomas H. Close, Patent Legal Staff, Eastman Kodak Company, 343 State Street, Rochester, NY 14650-2201. Please Direct all telephone calls to Thomas H. Close at (716) 722-2396.

The filing fee has been calculated as shown below:

FOR:	NO. FILED		NO. EXTRA	RATE	FEE
BASIC FEE					$ 690
TOTAL CLAIMS	24	- 20 =	4	x 18 =	$ 72
INDEPENDENT CLAIMS	2	- 3 =	0	x 78 =	$ 0
[ ] MULTIPLE DEPENDENT CLAIM PRESENTED				+ 260	$0
				TOTAL	$ 762

[X] Please charge my Eastman Kodak Company Deposit Account No. **05-0225** in the amount of $ 762.
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[X] The Commissioner is hereby authorized to charge any additional filing fees required under 37 CFR 1.16 or credit any overpayment to Eastman Kodak Company Deposit Account No. **05-0225.**
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PATENT APPLICATION BASED ON:

Docket No: 81,225

Inventors: Nathan D. Cahill
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Attorney: Thomas H. Close

LOCATION OF EXTENDED LINEAR DEFECTS

Commissioner for Patents
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LOCATION OF EXTENDED LINEAR DEFECTS

FIELD OF THE INVENTION

The present invention relates to photography and more particularly to extended linear defect location on a photographic element in digital photofinishing applications.

BACKGROUND OF THE INVENTION

Extended linear defects in scanned renditions of images on photographic elements, such as film, commonly occur. Such defects include, but are not limited to scratches, digs, processing draglines, coating streakiness, coating waviness, scanner defects, etc. For example, during the manufacture of photographic elements, defects in the coating process can lead to narrow regions, referred to as streaks, along the length of the photographic element in which one or more of the light-sensitive layers are affected. Because of the affected layer or layers, there is a change in the amount of light-sensitive material and/or coupler in the streak region. This manifests itself in abnormal characteristic data in the streak region. In a second example, a dirt particle in a camera can lead to a developable latent image formed by pressure sensitization when film is transported over the dust particle which is manifested as an extended linear defect.

The use of reference calibration patches exposed on a roll of film to enable better exposure control during optical printing is known in the art. See for example U.S. Patent No. 5,767,983 issued June 16, 1998 to Terashita entitled ***Color Copying Apparatus for Determining Exposure Amount from Image Data of an Original Image and a Reference Image.*** The use of reference calibration patches has also been shown to be useful in determining correction values for scanned film data used in digital printing. See for example U.S. Patent No. 5,667,944 issued September 16, 1997 to Reem et al. entitled ***Digital Process Sensitivity Correction***; and U.S. Patent No. 5,649,260 issued July 15, 1997 to Wheeler et al. entitled ***Automated Photofinishing Apparatus***.

Although extended linear defects can lead to undesirable artifacts in images of scenes, the effects of such defects when they occur in reference calibration images containing sensitometrically exposed patches can be even more detrimental. If such defects can be detected and located, the location of the image defect can be fed into software intended to measure sensitometric patches, enabling such software to avoid using data derived from the defective region or apply appropriate reconstruction techniques to recover affected data.

In the prior art, U.S. Patent No. 5,736,996 issued April 7, 1998 to Takada et. al., entitled ***Image Reading Apparatus with a Function for Correcting Nonuniformity in Recording Density***, and U.S. Patent No. 5,189,521 issued February 23, 1993 to Ohtsubo et. al. entitled ***Image Forming Apparatus and Method for Correction Image Density Non-Uniformity by Reading a Test Pattern Recorded by the Apparatus***, describe methods of automatically detecting image nonuniformities by laying down a test target on a recording medium. However, the nonuniformites of interest are inherent to a recording head and not the presumably uniform medium onto which the image is recorded. Once a nonuniformity is detected, the recording head is automatically calibrated to deliver uniform densities to the recording medium despite nonuniformities in the recording head. This prior art fails to repair the nonuniformity when such defects arise in the recording medium rather than the recording device or occur after the recording step, as the location and severity of the defects in the medium cannot be determined at the time of printing reference calibration targets.

Standard techniques for locating linear objects in digitized images, illustratively image segmentation and description techniques as described in Digital Image Processing by Rafael Gonzalez and Paul Wintz, Addison-Wesley Publishing Company, Reading, MA, 1977, may be applied to locate such defects in a nominally uniform sensitometric patch. However, in patches with exposures which exhibit low signal to noise ratios, such detection algorithms break down. Failure to detect a defect in such a patch could lead to bias in estimates of density or noise levels in the patch. Use of corrupted data in a calibration procedure could affect entire images in a deleterious fashion. Further, in highly structured

nonuniform images such as two-dimensional barcodes, these standard techniques fail to reliably distinguish between linear features that are part of the barcode and those that arise from an artifact.

Accordingly there is a need for an improved method to detect and locate linear defects in scanned images of photographic elements.

SUMMARY OF THE INVENTION

The need is met according to the present invention by providing a method of locating a linear defect on a photographic element, the element having a useful imaging width and the defect aligned with length of the element, that includes the steps of: exposing a region of the element to create a latent image which is substantially uniform across the useful imaging width of the element; developing the latent image to produce a density signal; sampling the density signal with a photometric device; and analyzing the sampled density data for the presence of significant deviations aligned with the length of the element to locate the defect.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of a film strip comprising a defect detection exposure according to the present invention;

Fig. 2 is a diagram comprising the steps in a method for defect detection according to the present invention; and

Fig. 3 is a diagram useful in discussing an analysis step according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

According to the present invention, a region spanning the width of a typical exposure region on a photographic element, for example the useful width of a film frame on a film strip, is exposed with a sufficiently uniform exposure.

A photographic element includes at least a base with a photosensitive layer that is sensitive to light to produce a developable latent image. The photosensitive layer may contain conventional silver halide

chemistry, or other photosensitive materials such as thermal or pressure developable chemistries. It can have a transparent base, a reflective base, or a base with a magnetically sensitive coating. The photographic element can be processed through standard chemical processes, including but not limited to Kodak Processes C-41 and its variants, ECN-2, VNF-1, ECP-2 and its variants, D-96, D-97, E-4, E-6, K-14, R-3, and RA-2SM, or RA-4; Fuji Processes CN-16 and its variants, CR-6, CP-43FA, CP-47L, CP-48S, RP-305, RA-4RT; Agfa MSC 100/101/200 Film and Paper Processes, Agfacolor Processes 70, 71, 72 and 94, Agfachrome Processes 44NP and 63; and Konica Processes CNK-4, CPK-2-22, DP, and CRK-2, and Konica ECOJET HQA-N, HQA-F, and HQA-P Processes. The photographic element can be processed using alternate processes such as apparently dry processes that may retain some or all of the developed silver or silver halide in the element or that may include lamination and an appropriate amount of water added to swell the photographic element. Depending upon the design of the photographic element, the photographic element can also be processed using dry processes that may include thermal or high pressure treatment. The processing may also include a combination of apparently dry, dry, and traditional wet processes. Examples of suitable alternate and dry processes include the processes disclosed in: U.S. Serial Nos. 60/211,058 filed June 3, 2000 by Levy et al.; 60/211,446 filed June 3, 2000 by Irving et al.; 60/211,065 filed June 3, 2000 by Irving et al.; 60/211,079 June 3, 2000 by Irving et al.; EP Patent No. 0762201A1 published March 12, 1997, by Ishikawa et al., entitled ***Method of Forming Images***; EP Patent No. 0926550A1, published December 12, 1998, by Iwai, et al., entitled ***Image Information Recording Method***; U.S. Patent No. 5,832,328 issued November 3, 1998 to Ueda, entitled ***Automatic Processing Machine for a Silver Halide Photographic Light-sensitive Material***; U.S. Patent No. 5,758,223 issued May 26, 1998 to Kobayashi, et al., entitled ***Automatic Processing Machine for Silver Halide Photographic Light-sensitive Material***; U.S. Patent No. 5,698,382 issued December 16, 1997 to Nakahanada, et al., entitled ***Processing Method for Silver Halide Photographic Light-sensitive Material***; U.S. Patent No. 5,519,510 issued May 21, 1996 to Edgar, entitled

Electronic Film Development; and U.S. Patent No. 5,988,896 issued November 23, 1999 to Edgar, entitled ***Method and Apparatus for Electronic Film Development***. It is noted that in the processes disclosed by Edgar, development and scanning of the image occur simultaneously. Accordingly, it is the intent of the present invention that any development and scanning steps can be performed simultaneously.

Once the photographic element has been processed and the sample image digitized, all of the pixel values, or a cross-section spanning the width of the exposure region, are compared. If a small region of pixels parallel to the length of the photographic element exhibits values throughout that differ significantly from values exhibited in the other areas of the uniform exposure region, a linear defect has been located in the corresponding position on the photographic element.

Referring to Fig. 1, in a preferred embodiment, a reference image of sufficiently uniform exposure **12** is exposed onto a photographic film strip **10** so that the reference image spans the width of an image frame **14**.

Preferably for detection of coating defects, the exposure level is chosen to be high enough that all layers of the film are actively involved in producing density upon development of the latent image formed by the exposure. Preferably for detecting additional density induced by local pressure variation or scratches, the exposure level is chosen low enough that additional density due to such sources is visible above the overall density of the reference image. For example, for Advantix 200 film manufactured by Eastman Kodak Company, Rochester, New York, an appropriate exposure is adequate to produce a density of 1.5 above Dmin. In this case, where the photographic element is a color negative photographic film having a plurality of layers, the exposure is high enough to produce a latent image that is developable in all layers of the film and low enough to produce a latent image that upon development allows detection of any additional density due to a defect. The same principle applies for any multilayer negative film, including for example, any multilayer monochrome film.

It may not be possible to choose a single exposure level that satisfies both of the above noted requirements. In such a case, a plurality of exposure levels varying along the length of the film strip can be used.

Referring to Fig. 2, the steps in the method for locating a longitudinal linear defect are described. A uniform exposure **12** is first exposed (**20**) onto a photographic film strip to record a latent image. The film strip is next processed (**22**) to produce a density signal from the recorded latent image. Then, a sampled image is generated (**24**) through photometric measurements, preferably by scanning the developed image with a film scanner and digitizing the output of the scanner. The sampled image is then analyzed (**26**) in order to determine if there are any regions where the uniformity differs from that of the uniform exposure **12**. If any such regions are found that are aligned with the length of the film strip, a linear defect has been located (**28**).

Referring to Fig. 3, a widthwise scan **34** of a digital image of the image frame **14** through the uniform exposure **12** is analyzed by observing the values **36** at each pixel. If a few values **38** differ significantly from the rest of the values **36** in other areas of the scan, a defect has been detected. If multiple scans through the uniform exposure **12** exhibit a defect in the same widthwise location, the defect is located and categorized as a linear defect. Multiple scan lines can be averaged and a similar process applied to the averaged scan lines to enhance the detectability of a linear defect.

When a defect has been located, the location can be used in image analysis software to improve the appearance of an image, or in the case of a reference calibration image to improve the reliability of the calibration data.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

PARTS LIST

10	photographic film strip
12	uniform exposure
14	image frame
20	exposure step
22	process step
24	generate sampled image step
26	analyze sampled image step
28	located defect step
34	width-wise scan
36	pixel values
38	defect location pixel values

WHAT IS CLAIMED IS:

1. A method of locating a linear defect on a photographic element, the element having a useful imaging width and the defect aligned with length of the element, comprising the steps of:

a) exposing a region of the element to create a latent image which is substantially uniform across the useful imaging width of the element;

b) processing the latent image to produce a density signal;

c) sampling the density signal with a photometric device; and

d) analyzing the sampled density data for the presence of significant deviations aligned with the length of the element to locate the defect.

2. The method in claim 1, wherein the exposing step comprises exposing a plurality of regions, whereby the likelihood of locating defects is enhanced.

3. The method in claim 1, wherein the exposing step comprises exposing a multiplicity of exposure levels varying along the length of the element, whereby a linear defect may be localized in exposure.

4. The method in claim 1, wherein the analyzing step comprises averaging of samples aligned with the length of the element, whereby the significance of a nonuniformity is enhanced.

5. The method claimed in claim 1, wherein the photographic element is a negative photographic film having a plurality of layers and the exposure is high enough to produce a latent image that is developable in all layers of the film.

6. The method claimed in claim 1, wherein the photographic element is a negative photographic film and the exposure is low enough to produce a latent image that upon development allows detection of any additional density due to a defect.

7. The method claimed in claim 1, wherein the photographic element is a negative photographic film having a plurality of layers and the exposure is high enough to produce a latent image that is developable in all layers of the film and the exposure is low enough to produce a latent image that upon development allows detection of any additional density due to a defect.

8. The method claimed in claim 7, wherein the exposure is sufficient to produce a developed image that is 1.5 above Dmin.

9. The method claimed in claim 1, further comprising the step of employing the location of the defect in processing a digital image derived from the photographic element.

10. The method claimed in claim 1, wherein the photographic element is a film strip.

11. The method claimed in claim 1, wherein the processing step employs a standard photographic process.

12. The method claimed in claim 1, wherein the processing step employs an alternate photographic process.

13. The method claimed in claim 1, wherein the processing step employs a dry photographic process.

14. The method claimed in claim 13, wherein the dry photographic process includes thermal treatment.

15. The method claimed in claim 13, wherein the dry photographic process includes high pressure treatment.

16. A photographic element having a useful imaging width, the element including a latent image which is substantially uniform across the useful imaging width of the element for use in locating a linear defect aligned with the length of the element.

17. The photographic element claimed in claim 16, wherein the photographic element is a negative photographic film having a plurality of layers and the exposure is high enough to produce a latent image that is developable in all layers of the film.

18. The photographic element claimed in claim 16, wherein the photographic element is a negative photographic film and the exposure is low enough to produce a latent image that upon development allows detection of any additional density due to a defect.

19. The photographic element claimed in claim 16, wherein the photographic element is a negative photographic film having a plurality of layers and the exposure is high enough to produce a latent image that is developable in all layers of the film and the exposure is low enough to produce a latent image that upon development allows detection of any additional density due to a defect.

20. The photographic element claimed in claim 19, wherein the exposure is sufficient to produce a developed image that is 1.5 above Dmin.

21. The photographic element claimed in claim 16, wherein the photographic element includes a photosensitive layer that contains conventional silver halide chemistry.

22. The photographic element claimed in claim 16, wherein the photographic element includes a photosensitive layer that contains thermal developable chemistry.

23. The photographic element claimed in claim 16, wherein the photographic element includes a photosensitive layer that contains pressure developable chemistry.

24. The photographic element claimed in claim 16, wherein the photographic element is a film strip.

ABSTRACT OF THE DISCLOSURE

A method of locating a linear defect on a photographic element, the element having a useful imaging width and the defect aligned with length of the element, includes the steps of: exposing a region of the element to create a latent image which is substantially uniform across the useful imaging width of the element; developing the latent image to produce a density signal; sampling the density signal with a photometric device; and analyzing the sampled density data for the presence of significant deviations aligned with the length of the element to locate the defect.

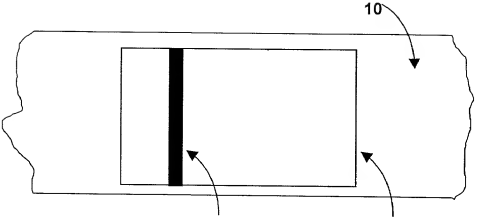

FIG. 1

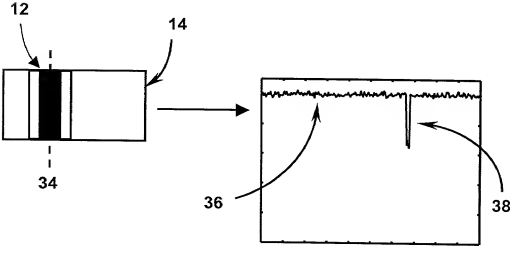

FIG. 3

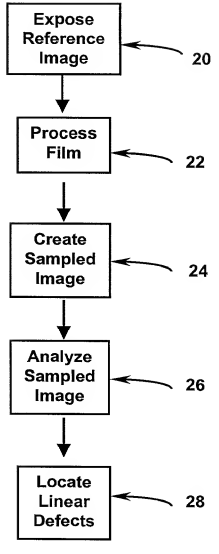
Expose Reference Image
20
Process Film
22
Create Sampled Image
24
Analyze Sampled Image
26
Locate Linear Defects
28

FIG. 2

Combined Declaration For Patent Application and Power of Attorney

ATTORNEY DOCKET 81225THC

As below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

LOCATION OF EXTENDED LINEAR DEFECTS

The specification of which (check only one item below):

[X] is attached hereto.

[ ] was filed as United States Application Serial No. on and was amended on (if applicable).

[ ] was filed as PCT international application Number on and was amended under PCT Article 19 on (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the U.S. Patent & Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign applications(s) for patent or inventor's certificate or any PCT international application(s) designating a least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT, indicate PCT)	APPLICATION NUMBER	DATE OF FILING (day month year)	PRIORITY CLAIMED UNDER 35 USC 119			
				YES		NO
				YES		NO
				YES		NO

I hereby claim the benefit under Title 35, United States Code, 119 §(e) of any United States provisional application(s) listed below:

PRIOR PROVISIONAL APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. §119 (e):

PROVISIONAL APPLICATION NUMBER	FILING DATE

I hereby claim the benefit under Title 35, United States Code, §120 of any prior United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior applications(s) in the manner provided by the first paragraph of Title 35, §112, I acknowledge the duty to disclose to the U.S. Patent & Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations §1.56, which became available between the filing date of the prior application(s) and the national or PCT international filing date of this application.

PRIOR US APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S FOR BENEFIT UNDER 35USC§120:

U.S. APPLICATIONS		STATUS (Check one)		
U.S APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.				
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)		

Combined Declaration For Patent Application and Power of Attorney *(Continued)* | **ATTORNEY DOCKET 81225THC**

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(List name and registration number)*

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2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
3	BUSINESS ADDRESS	BUSINESS ADDRESS	CITY	STATE & ZIP CODE (COUNTRY)
2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
4	BUSINESS ADDRESS	BUSINESS ADDRESS	CITY	STATE & ZIP CODE (COUNTRY)
2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
5	BUSINESS ADDRESS	BUSINESS ADDRESS	CITY	STATE & ZIP CODE (COUNTRY)
2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
6	BUSINESS ADDRESS	BUSINESS ADDRESS	CITY	STATE & ZIP CODE (COUNTRY)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE 8/8/2000	DATE 8/8/2000	DATE
SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205	SIGNATURE OF INVENTOR 206
DATE	DATE	DATE